ARTICLE V
STORM DRAINAGE SYSTEMS

501.00 SPECIAL DEFINITION OF ADEQUATE STORM DRAINAGE SYSTEMS

Adequate drainage systems are those which have the hydraulic characteristics to accommodate the maximum expected flow of storm waters for a given watershed or portion thereof for a specified duration and intensity of rainfall. Said systems (1) should be designed to account for both off-site and on-site storm waters, including storm waters coming onto a given tract of land from upstream, (2) should discharge said water into the natural drainageway, and (3) should carry said water to a point where it will flow by gravity downstream into a stream, channel, or drainageway, or where it can be connected into existing facilities of sufficient capacity as determined by the Director to receive the same. In general, drainage facilities should not be terminated short of the property line unless an adequate outfall exists there. Drainage structures should be constructed in such a manner that they can be maintained at reasonable cost. To facilitate design, construction, and maintenance, said systems should meet or conform to this Manual and Virginia Department of Transportation Standards.

Determination of the size and capacity of a drainage structure should take into account the ultimate planned development in the watershed or the affected portions thereof. The design should not adversely affect adjacent or neighboring properties.

502.00 GLOSSARY FOR HYDRAULICS AND DRAINAGE

(From Virginia Department of Transportation: the following were extracted from various publications or texts, having a more extensive glossary for the subjects of hydrology, and drainage)

ACRE-FOOT - Quantity of water that would cover 1 acre, 1 ft. deep. An acre-foot contains 43,560 cu. ft.

APPROACH CHANNEL - The reach of channel upstream from a dam, bridge, construction, culvert, or other structure.

APPROACH SECTION - A cross section of a stream channel, normal to thread of current, located in the approach channel.

APRON - A floor or lining of concrete to protect a surface from erosion, such as the pavement at the outlet of culverts or storm sewers.

BACKWATER - (A) In a general sense, a flow retarding influence due to a dam, other constriction such as a bridge or culvert, or another stream; (B) the

increase in water surface elevation due to a bridge constriction above the normal unconstricted elevation, at an approach section located one bridge length upstream from the bridge constriction.

BACKWATER CURVE - A particular form of the surface curve of a stream of water which is concave upward. It is caused by an obstruction in the channel such as an overflow dam: the depth is greater at all points than Belanger's critical and the normal depths; and the velocities diminish downstream. The term is used in a generic sense to denote all water surface curves.

BERM - The space left between the upper edge of a cut and toe of an embankment to break the continuity of an otherwise long slope.

BRIDGE - A structure erected over a watercourse, depression, or obstacle (Webster's Collegiate Dictionary). As distinguished from a culvert it is a large structure spanning a watercourse, the bed of which is left comparatively undisturbed. The opening width is generally large compared to length (in the direction of flow). The structure generally consists of a deck or super-structure supported on two, or more, abutments, or piers.

CATCHMENT AREA OR BASIN - Watershed; drainage basin; also, the area of such a basin.

CHANNEL - An elongated open depression in which water may, or does, flow. An elongated depression, either naturally or artificially created and of appreciable size, which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. It must have a definite bed and bank which serve to confine the water.

CHANNEL COEFFICIENT - A roughness factor in the Kutter, Manning, Bazin, and other formulas expressing the character of a channel as affecting the friction slope of water flowing therein. More specifically, the roughness factor (n) in the Manning formula.

COEFFICIENT OF ROUGHNESS - See CHANNEL COEFFICIENT.

CONDUIT - A general term for any channel intended for the conveyance of water, whether open or closed., any container for flowing water.

CONTROL - A section or a reach of a conduit where conditions exist that make the water level about it a fairly stable index of discharge. A control may be partial or complete. A complete control is independent of downstream conditions and is effective at all stages. An overflow dam, a ledge of rock crossing a channel, a boulder-covered reach, an indurated bed, are examples.

Controls may be either natural or artificial.

CRADLE - A footing structure shaped to fit the conduit it supports.

CREST - (A) The top of a dam, dike, spillway, or weir; frequently restricted to the overflow portion; (B) the summit of a wave; peak of a flood.

CRITICAL DEPTH - A given quantity of water in an open conduit may flow at two depths having the same energy head. When these depths coincide, the energy head is a minimum and the corresponding depth is Belanger's critical depth. It is the depth at which, for a given energy content of the water in a channel, maximum discharge occurs; or the depth at which in a given channel a given quantity of water flows with minimum content of energy.

CULVERT - A culvert is a closed conduit of waterway carrying water through a highway or railroad embankment. Although there are border-line cases, a culvert is distinguished from a bridge by certain characteristics, such as (a) a culvert generally has the same material all around its perimeter, and has a regular, symmetrical shape, where a bridge opening has not - in other words, a culvert is a large pipe; (b) a culvert usually has a large ratio of length to width.

CUT-OFF - A wall, collar, or other structure intended to reduce percolation of water along otherwise smooth surfaces, or through porous strata.

DEBRIS - Any material, including floating trash, suspended sediment, or bed load, moved by a flowing stream; detritus.

DIKE - An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of low lands; a levee.

DISCHARGE - (A) The quantity of water, silt, or other mobile substances passing along a conduit per unit of time; rate of flow; cubic feet per second; liters per second, millions of gallons per day, etc. (B) The act involved in water or other liquid passing through an opening or along a conduit or channel. (C) The water or other liquid which emerges from an opening or passes along a conduit or channel.

DITCH - An artificial channel, usually distinguished from a canal by its smaller size.

DRAINAGE AREA - The drainage area of a stream at a specified location, measured in a horizontal plane, which is enclosed by a typographic divide such that direct surface runoff from precipitation normally would drain by gravity into the river basin above the specified point.

DROP - (A) A structure for dropping the water in a conduit to a lower level and dissipating its surplus energy. A drop may be vertical or inclined; the latter is called a chute; (B) a fall. Also the drop or fall (h) in water surface elevation between the upstream and downstream (between headwater and tailwater) sides of a bridge construction or submerged culvert. or between two sections of a slope reach.

ENERGY - The capacity to perform work; kinetic energy is that due to motion; and potential energy is that due to position. In a stream the total energy at any section is represented by the sum of its potential and kinetic energies.

ENERGY GRADIENT - The slope of the energy line with reference to any plane.

ENERGY HEAD - The elevation of the hydraulic grade line at any section plus the velocity head of the mean velocity of the flow in that section. The energy head may be referred to any datum, or to an inclined plane, such as the bed of a conduit. Total head above datum at any cross section.

ENERGY LINE - A line joining the elevations of the energy heads of a stream. The energy line is above the hydraulic grade line a distance equivalent to the velocity heads at all sections along the stream. A line representing the energy in flowing water. It is plotted a distance equal to depth plus velocity head above a profile of the flow line of a conduit. The slope of this line represents the rate of loss of head and it must always slope downward in the direction of flow.

ENTRANCE LOSS - The head lost in eddies and friction at the inlet to a conduit or structure.

FLOOD PEAK - The maximum discharge of a particular flood at a given point along a stream.

FLOOD PLAIN - Any plain which borders a stream and is covered by its water in time of flood; stream bed areas subject to recurrent overflow, or inundation.

FLOOD ROUTING - (RESERVOIR ROUTING) - Determination of the hydrograph for a particular site in a surface channel on the basis of hydrograph data for another site some distance up or downstream. NOTE: Flood routing is generally used to determine changes made in flood hydrograph by the floods passing through a stream reach or reservoir.

FLOODWAY - The channel of a river, stream or other watercourse and the adjacent land area that must be reserved to discharge the 100-year flood without cumulatively increasing the water surface elevation more than one foot at any

point.

FREQUENCY CURVE - A graphical representation of the frequency of occurrence of specific events. In flood studies, frequency is expressed as recurrence interval which is the average number of years within which a given peak discharge or rainfall intensity will be equalled or exceeded.

FRICTION LOSS (OR HEAD) - The head or energy loss as the result of disturbances set up by the contact between a moving stream of water and its containing conduit. For convenience friction losses are best distinguished from losses due to bends, expansions, obstruction, impacts, etc., but there in no recognized line of demarcation between them, and all such losses are often included in the term "friction loss".

HEAD - The height of water above any point or plane of reference. Used also in various compounds, such as energy head, entrance head, friction head, static head, pressure head, lost head, etc.

HEAD-WATER - (A) The water upstream from a structure; (B) the source of a stream.

HYDRAULIC GRADE LINE- In a closed conduit a line joining the elevation to which water could stand in risers. In an open conduit, the hydraulic grade line is the water surface; piezometric head line.

HYDRAULIC GRADIENT - The slope of the hydraulic grade line; the slope of the water surface in uniform, open-channel flow.

HYDRAULIC JUMP - The sudden and usually turbulent passage of water from a stage below critical depth to a stage above critical depth during which the velocity passed from supercritical to subcritical. It represents the limiting conditions of the surface curve wherein it tends to become perpendicular to the stream bed.

HYDROLOGY - The science dealing with the waters of the earth in their various forms; precipitation, evaporation, run-off, and ground water.

IMPERVIOUSNESS - That quality or condition of a material that minimizes percolation.

INVERT - The floor, bottom, or lowest part of the internal cross-section of a conduit.

KINETIC ENERGY - Energy due to motion. The kinetic energy of a given

discharge is generally taken as proportional to the product of its weight per unit of time and the velocity head of its mean velocity. For a constant discharge, kinetic energy may be represented by a line at a distance above a flowing water surface proportional to the velocity head of its mean velocity. The elevation of such a line above any datum represents the total energy (potential plus kinetic) of the given discharge above that datum. Strictly, the kinetic energy of a given discharge is the integral of the kinetic energies of its particles.

OPEN-CHANNEL FLOW - Flow in any open or closed conduit where the water surface is free; that is, where the water surface is at atmospheric pressure.

PRECIPITATION - The total measurable supply of water received directly from the clouds, as rain, snow, and hail; usually expressed as depth in a day, month, or year, and designated as daily, monthly, or annual precipitation.

REACH - A comparatively short length of a stream or channel.

RUN-OFF COEFFICIENT - The rate of run-off to precipitation.

SECOND-FOOT - A cubic foot per second; optional usage, cu. ft. per sec.; cfs.

SPECIFIC ENERGY - The energy of a stream referred to its bed; namely, depth plus velocity head of mean velocity.

STORM SEWER - A sewer that carries only storm water, drainage and other water from the surface of the street, but not domestic sewage or industrial wastes; is commonly known as a storm sewer. NOTE: A storm sewer system consists of underground conduits, inlets, manholes, open channels, swales, and special appurtenances.

TAIL-WATER - The water just downstream from a structure.

TIME OF CONCENTRATION- The estimated time required for run-off to flow from the most remote section of the drainage area to the point at which the discharge is to be determined.

VELOCITY HEAD - The distance a body must fall freely under the force of gravity to acquire the velocity it possesses; the kinetic energy, in feet of head, possessed by a given velocity.

503.00 CRITERIA FOR DESIGN OF STORM DRAINAGE SYSTEMS

503.01 Rational Formula: The rational method shall be used for all stormwater drainage design (for drainage areas less than 200 acres)